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Treatment Manual

Nonchemical Treatments

Heat • Hot Water Immersion Treatment

Contents

Hot Water Immersion Treatment (in General)

Principle

Hot water immersion treatment (also called hydrothermal treatment) uses heated water to raise the temperature of the commodity to the required temperature for a specified period of time. This is used primarily for certain fruits that are hosts of fruit flies, but may also be used for nursery stock for a variety of pests.

Schedules

Refer to the appropriate section in the Treatment Manual for treatment schedules. The time-temperature relationship varies with the commodity and pest. Typically, the pulp temperature is raised using water heated to between 115 and 118 °F for a prescribed period of time.

Procedures

All treatments will be conducted in an approved tank.

The facility will be checked for proper operation of the heating, circulation, and recording equipment before the start of each treatment. Continuous flow equipment (submerged conveyor belt) will be checked at the start of each day or run.

Commodity will not be refrigerated before treatment, and must be at or above the prescribed minimum temperature if specified in the treatment schedule.

Commodities subject to size restrictions require a preliminary culling procedure to eliminate oversized items prior to treatment.

Immersion tanks will be loaded in a manner approved by the U.S. Department of Agriculture (USDA), usually using baskets with perforations that allow adequate water circulation and heat exchange.

Each treatment container or lot shall be given an identifying number before bring placed in the immersion tank.

An automatic temperature recording system shall record the temperature and duration of each hot water dip. A responsible employee of the packing company shall indicate on the printed temperature record the starting time, lot number, duration of each treatment and initial each entry. An alternative recording system may be used only with prior APHIS approval.

All boxes of hot water treated fruit will be stamped *Treated with Hot Water, APHIS-USDA,* together with the numerical designation that APHIS has assigned to the particular treatment facility.

Commodities treated at origin will be moved to an insect free enclosure promptly after treatment and maintained insect-free throughout the shipping process. This may be accomplished by using insect-proof containers, screened or enclosed rooms, doors with air-curtains, or some combination of these.

The entire treatment shall be under the general monitoring of APHIS, and may be further governed by a signed Work Plan (for foreign facilities) or Compliance Agreement (for domestic facilities).

Checklist Of USDA-APHIS Minimum Requirements for Hot Water Immersion Treatment Facilities: General Requirements

Submission of proposals

In submitting proposals for new hot water facilities, the accepted protocol must be followed. (Under Certifying Facilities," see the discussion under "Certification of How Water Immersion Facilities - Protocols for Foreign Treatment Facilities.")

On site inspection option

When the construction is 75% completed, the firm may request APHIS to make an on-site inspection. This interim inspection is optional. However, a final inspection is required as well as performance tests of the equipment. All costs involved must be prepaid by the requesting firm.

Design of the facility

APHIS does not provide construction details, but only this checklist of minimum requirements. Design and construction of the hot water facility is the responsibility of the owner, in consultation with an engineering firm. (Engineering firms and sources of supply are

provided in Appendix B.) APHIS allows a wide range of design flexibility, to take into account variations in facility size, availability of materials, economic feasibility, and individual preference.

There are two basic designs for hot water facilities, although each facility is somewhat unique. The two types are referred to as the *batch system* and the *continuous flow system*.

Batch system (sometimes called "Jacuzzi system")

Most hot water immersion treatment facilities are of this type. In this system, baskets of fruit are loaded onto a platform, which is then lowered into the hot water immersion tank, where the fruit remain at the prescribed temperature for a certain length of time, then are taken out, usually by means of an overhead hoist. In this system, the treatment chart must indicate (by an identifiable marking) when a fruit basket is prematurely removed from the tank. Other alternatives include a solenoid switch, sensor or similar device that disengages whenever a basket is removed from the treatment tank, or a locking device to make it physically impossible to remove the fruit until the treatment is fully completed.

Continuous flow system

In this type of system, the fruit are submerged (either loosely or in wire or plastic mesh baskets) on a conveyor belt, which moves slowly from one end of the hot water tank to the other. Belt speed is set to insure that the fruits are submerged for the required length of time. This system requires an instrument to monitor the speed of the conveyor belt. This can be accomplished by attaching a speed indicator (encoder) to the gear mechanism. The belt speed is recorded on the same chart as the time and temperature, and also indicates whether the belt is moving or stopped during the treatment cycle. Smaller fruits require less treatment time than larger fruits. Therefore, conveyor belt speed should be adjustable to accommodate treatments of different lengths of time. As an alternative, the belt speed may remain constant, but the length of the submerged portion of the belt is adjusted according to the length of treatment time required for the particular size of fruit. The conveyor must prohibit either forward or backward movement of the fruit during treatment (due to flotation).

Some operators believe that treating fruit while it passes through the system on a conveyor belt is an advantage. Few new systems of this type were built after 1990, presumably because mechanical fruit damage (scratching of the peel) often occurs. if the fruit are not in baskets. The system also occupies much more floor space in the plant than a batch system.

Water Quality

Prevention of microbial contamination of fruit at the plant is expected. Any water used for washing, dipping, or showering the fruit should be chlorinated, and maintained at a level of 50 to 200 ppm parts per million. Also, hydrocooling tanks must be chlorinated to the same level. This level is easier to maintain if the water is first filtered and run through a flocculation process to remove organic material which

would otherwise bind with the chlorine. Water should be sampled regularly for microbial contamination. Water should be changed, as necessary, to maintain sanitary conditions. Standard operating procedures should be implemented to include water change schedules for all processes that use water. In addition, surfaces that come into contact with water, such as wash tanks, hot water tanks, and hydro cooling tanks should be cleaned and sanitized as often as necessary to ensure the safety of the produce. Equipment designed to assist in maintaining water quality, such as chlorine injectors, filtration systems and back flow device's, should be routinely inspected and maintained to ensure efficient operation.

Periodic monitoring is critical, because chlorine levels above 300 ppm may result in metal corrosion

Electrical and Electronic Components

Wiring

Electrical wiring throughout the facility must meet both international as well as local safety code requirements. Earth grounding is required for all electrical wiring located in the vicinity of water, to eliminate shock hazard. Wires must be shielded inside metal or PVC conduit to prevent damage.

Computers and microprocessors

These shall be located in a climate-controlled (air-conditioned) room, to maintain accuracy and reliability. This room shall be raised above tank level, and provide a clear view of the treatment tank(s), and be capable of being locked. This room may also serve as an office for the inspector.

Commercial line conditioner (surge protector)

This is recommended for use with computers and microprocessors, to provide protection from voltage irregularity (power surges), noise reduction, and harmonic distortion.

Electrical generator

This is recommended for use as a back-up power supply, in the event of a power outage, to provide a secondary source of electricity to enable continued operation of the plant.

Fruit Sizing Equipment

In the treatment schedule, the duration of hot water immersion depends upon the particular weight class of the fruit being processed. It is very important to have accurate sizing equipment that sorts the

fruit into groups, either by diameter or by weight. (Weight sorting is the preferred method.) Not more than 10% of the fruit in any batch are allowed to weigh more than the maximum weight for their particular weight class. Of these, none are allowed to be more than 25 grams over weight. The APHIS inspector shall periodically record the weights of 100 fruits in a particular batch that has been sorted prior to treatment to be sure that the accuracy of the sizing equipment stays within these parameters. If the weight range is too broad, some calibration adjustment will be required on the equipment. Since it is possible for the immature stages of fruit flies to survive in fruit that are under-treated for their weight, it is especially important to assure that all fruits are sorted accurately into precise weight classes, as required by the treatment.

Boilers and Thermostatic Controls

Adequate water heating capacity

The hot water facility must have adequate water heating capacity (i.e., a boiler powerful enough), and thermostatic controls accurate enough to hold the water temperature at or above the temperatures prescribed in the treatment schedule for the given duration of time. A boiler used for the purpose of heating the water in a two-tank batch system typically needs an output rating of approximately 1,000,00 BTU, or 30 horsepower.

Thermostatic controls (set point)

APHIS requires that the thermostatic controls should be automatic. The temperature set point(s) will be determined and approved during the official performance test, and shall be high enough to ensure that the water in the treatment tank will meet or exceed minimum treatment temperature prescribed for the fruit. Once approved, the temperature set points may not be tampered with. Temperature set points shall remain constant for the entire shipping season. However, if the operator of the facility requests a change in set points, the inspector shall conduct a new performance test. If this test is unsuccessful, then the tanks shall revert to using their prior set points.

Multiple set point option

Managers of some facilities prefer to use two set points for each tank. In this type of system the initial dip temperature (set point no. 1) is set slightly higher for the first 5 minutes. The second set point is the temperature to be maintained for the remainder of the treatment. This must be verified during the official performance test, and the same procedure must be repeated on each subsequent commercial treatment. The use of two set points is not required. However, this

arrangement makes it makes it easier for the tank to pass its performance test. This system works only for tanks that treat only one cage (basket) of fruit (basket) of fruit at a time.


Important

Tanks are not allowed to have any set point that is lower than the standard treatment temperature for the commodity being treated (115 °F in the case of mangoes).

Water Circulation

A water circulation system shall be installed in the tank, to provide uniform water temperatures throughout the treatment process and avoid the formation of cool pockets during treatment. The controls for the circulation pumps or propellers shall be tamper-resistant, to guarantee that the equipment is not turned off during the treatment process. Pulleys on all pumps located within 6 feet of the floor shall be shielded for the safety of personnel working in the area.

Temperatures recorded from the various sensors shall not vary by more than 1.8 °F (1 °C) at any given time after the fruit have been immersed for the first 5 minutes of treatment.

The fruit must be kept at least 4 inches (10.2 cm) below the water surface during the treatment, by use of a flotation barrier.

Temperature Sensors

Type of sensor

Platinum 100-ohm resistive thermal detectors (RTD sensors) are to be installed permanently in the lower third of the tank. The resistance of an RTD sensor changes linearly with temperature, whereas thermisters and thermocouples are non-linear, and less stable. Major advantages of RTD's include long-term stability, high signal levels, and overall accuracy of the system. The sensor unit shall be located within the distal one inch (2.54 cm) of the sensor rod. The sensor shall have an outer sheath of 0.25 inch (6.4 mm) in diameter or less.

Number of sensors required, and their placement

The minimum number required shall at least 10 per tank for continuous flow systems, which must be spaced throughout the length of the conveyor. For batch systems, the requirement is at least two sensors per tank. However, in tanks that treat multiple baskets (cages) of fruit there must be at least one sensor per basket position.

(A tank with 4 basket positions, for example, would require at least 4 sensors). In both the batch and continuous flow systems, sensors shall be installed in the lower third of the tank.

Tank access for temporary placement of portable sensors

The hot water tank must be designed to accommodate the temporary placement of numerous portable sensors or probes to be used during the performance testing procedure required for certification or re-certification. During the testing procedure, the temporary sensors shall be positioned throughout the load of fruit, at the direction of the inspector who conducts the performance test. The facility is required to purchase and have available, 24 portable thermistor or thermocouple sensors (each with its own flexible cord at least 10 ft. in length), and a portable temperature monitor which reads to the nearest one tenth of a degree.

Certified glass-mercury thermometer

The treatment facility is required to have at least one high-accuracy, water-immersible, certified glass-mercury stick thermometer on the premises at all times. This thermometer shall be accurate to 0.1 °F (or C), and will cover the range between 113 °F and 118 °F. It will be used as the standard against which all sensors are calibrated. Normally, one glass thermometer is left hanging in each tank during the performance testing procedure.

Temperature Recorder

An automatic temperature recorder (strip chart or data logger) shall be used to record the time and temperature during each treatment.

Automatic operation

The instrument used for recording the time and temperature must be capable of automatic operation whenever the hot water treatment system is activated.

Long-term recording

The recording equipment must be capable of non-stop recording for an extended period of time. Continuous flow systems require recording equipment capable of operating for up to twelve consecutive hours.

Recording frequency

The time interval between prints will be no less than once every two minutes. Alternatively, a strip chart system may be used which gives continuous color pen lines. The numerical print or pen line

representing each temperature channel (sensor) must be uniquely identified by color, number, or symbol. It is not necessary to record temperatures from sensors located in portions of the tank not in use.

Accuracy

The combined accuracy of the entire temperature recording system (i.e., sensors, controllers and recorders) must be within 0.5 °F (0.3 °C) of the true temperature (as verified by a certified glass mercury thermometer).

Repeatability

The recording equipment must be capable of repeatability to within 0.l °F of the true calibrated readings when used under field conditions over an extended period of time. Failure to maintain reliability, accuracy and readability in a previously approved instrument will result in cancellation of approval. The design construction and materials used shall be such that the typical environmental conditions (including vibration) will not affect performance.

Calibration

Channels (sensors) must be individually calibrated against a certified glass mercury thermometer reading in tenths of a degree F or C, within the range of 113 °F to 118 °F, (45 °to 47.8 °C). The engineering firm that installs the recording equipment shall also calibrate it. (Calibration equipment often used for this purpose includes, for example, a Decade instrument and relay range cards.) The calibration procedure should be done at or near the fruit-treatment temperature (around115 °F), but not at 32 °F.

Range

The recorder must be programmed to cover the entire range between 113 °F to 118 °F (45 ° to 47.8 °C), with a resolution of one-tenth of a degree. The range should not extend below 100 °F (37.8 °C) nor above 130 °F (54.4 °C). If the range band of the recorder is wider than this, it must be restricted (narrowed) by proper programming.

APHIS-approved recorder models

Some recorder models currently on the market are not approved by APHIS for various reasons. For example, they only display the sensor numbers and temperatures without making a print-out on paper; or they print out the temperature data only after the treatment has been completed. (These are known as “memory loggers.”). These two types of instruments do not provide an adequate level of monitoring during treatment, and are therefore not approved. *Also, revolving circular charts are not acceptable, because of the difficulty in reading fractions of one degree.*

Temperature recorder models presently approved by APHIS are listed below. They may be either of the strip chart or data logger type. Some have adjustable chart speeds. Additional temperature recorder models may be added to this list upon petition to Oxford Plant Protection Laboratory (OPPS). To seek APHIS approval for recorder models not listed, the manufacturer's technical brochure shall be submitted to OPPS for evaluation.

Approved strip chart (pen) recorder models

- Chessel 346
- Honeywell DPR 100A (3 channel capability)
- Honeywell DPR 100B (6 channel capability)
- Honeywell DPR 100C (3 channel capability)
- Honeywell DPR 100D (6 channel capability)
- Honeywell DPR 180 (36 channel capability)
- Honeywell DPR 1000 (6 channel capability) [1]
- Honeywell DPR-3000, version D4 (32 channel capability) [2]
- Honeywell Versaprint-131 (12 channel capability)
- Molytek 2702
- Neuberger P1Y
- Toshiba AR201
- Tracor 3000
- Yokogawa Micro-R l80

Approved data logger recorder models

- ASICS Systems B & C
- Chino AA Series
- Cole Parmer (32 channel capability)
- Contech (10 channel capability) [3]
- Flotek (must be attached to a printer)
- HACCP Warrior PTR- 4 (4 channel capability)
- HAACP Warrior PTR- 10 (10 channel capability)
- Honeywell DPR I00B (6 channel capability)[4]

1 The Honeywell DPR-3000 must be the high-accuracy version, with model number beginning with D4. It has the versatility of being used either as a strip chart or data logger.
2 The Honeywell Versaprint-131 was no longer manufactured after 1996.
3 The Flotek Company went out of business in 1991. However, used instruments occasionally become available, and a few new instruments may still be stocked by companies such as ASICS.
4 The Honeywell DPR-1500 was no longer manufactured after 1990.

- Honeywell DPR-1500 (30 channel capability) [5]
- Honeywell DPR-3000, version D4 (32 channel capability) [6]
- Flotek (must be attached to a printer)
- IBM-PC (must be attached to a printer)
- National Instruments (hardware + software) (64 channel capability)
- Nanmac H30-1
- Omega OM-205
- Omega OM-503
- Ryan Data Mentor (12 channel capability)
- Tracor Westronics DDR10

Chart paper specifications:

C or F scale

Temperature may be recorded either in Fahrenheit or Centigrade, although Fahrenheit is preferred by APHIS.

Scale deflection

Scale deflection on the strip chart paper shall be at least 0.10 inches for each degree Fahrenheit, or at least 5 mm for each degree Centigrade. Greater width between whole degrees, however, is preferred. Between each line representing one degree, there shall also be finer lines, each representing subdivisions of one-tenth, or two-tenths of a degree, in the range of 113 °F to 118 °F (45 °C to 47.8 °C).

Sample required

A sample of the strip chart or numerical printout made by the recording equipment must be submitted to Oxford Plant Protection Laboratory. It should be in the exact format to be used at the facility during the treatment cycle. Each symbol on the print wheel (or ink color, in the case of strip charts) must correspond to, and identify, the particular sensor that it represents.

Chart speed

Chart speed for strip chart recorders shall be no less than one inch for every ten minutes of treatment time. (One inch for every 5 minutes is preferred). Thus, for a typical 90 minutes of treatment the total length of the chart will be at least 9 inches long (preferably 18 inches).

Chart length

The chart paper shall be of sufficient length to display at least one entire treatment. Continuous flow systems must contain enough chart paper to continuously record temperatures for up to 12 consecutive hours.

5 The Honeywell DPR-3000 must be the high-accuracy version, with model number beginning with D4. It has the versatility of being used either as a strip chart or data logger.

6 The Flotek Company went out of business in 1991. However, used instruments occasionally become available, and a few new instruments may still be stocked by companies such as ASICS.

Alarm System

An alarm is required for all batch (Jacuzzi) systems. In order to notify packinghouse employees that a treatment has been completed for a particular basket (cage), an alarm system must be installed. This system may be an audible noise (such as a horn, buzzer, or bell), or a highly visible light, attached to a timing device located on the equipment that indicates time and temperature. Some facilities use both a noise and a light. The alarm system alerts the operator of the hoist to remove a basket from the tank at the end of treatment, to avoid "over-cooking."

Safeguarding the Treated Fruit

Layout and flow pattern

The flow pattern of the fruit moving through the hot water treatment process should be so designed that fruit waiting to be loaded into the hot water immersion tank cannot become mixed with fruit that has already completed treatment. A drawing that shows the proposed layout of the packinghouse shall be submitted to Oxford Plant Protection Laboratory for approval.

Garbage disposal

Cut fruit, culled fruit, rotting fruit, and miscellaneous garbage shall be placed into covered containers and removed form the premises daily, in order not to attract fruit flies.

Quarantine area

Treated fruit must be brought to an insect-free enclosure immediately after treatment, and must remain there until loading into insect-proof shipping containers. The designated enclosure is usually a screened room. Packing line equipment, hydro cooling equipment, and a cool storage room (if any), should be located in this area, but this equipment is not a requirement. Effective procedures shall be enforced to prevent the movement of untreated fruit (accidentally or intentionally) into the insect-free quarantine area.

Screening and other materials

Ordinary window screen or mosquito netting (at least 100 mesh per square inch) is sufficient to exclude fruit flies. It must be inspected regularly and repaired as often as needed. Solid glass, concrete, drywall, or wooden walls are also acceptable.

Air curtain

Apparatus that generate a high-velocity wind barrier or air curtain (such as fans or blowers and associated air-directing chambers or enclosures such as baffles, boxes, etc.) shall be located on the wall or ceiling prior to entering any quarantine area. This device shall exclude the possible entry of fruit flies into the insect-free enclosure. (On

facilities approved prior to July 1, 1997, vertically hanging, clear plastic flaps are required at the doors to the insect-free enclosure, as a minimum.)

Loading of treated fruit

Doors leading from the quarantine area to the loading dock shall be kept closed when not in use. When loading, truck vans and containers shall form a fly-proof seal with the exterior wall. Truck vans and containers shall be inspected and disinfected prior to loading. If wooden pallets are used, they must be completely free from weed-infesting insects and bark. A numbered APHIS seal shall be applied to each container before its departure.

Pre-treatment Warming Options

Pre-warming the fruit is sometimes desirable in order to meet the APHIS requirement that all fruit pulp temperatures must be at least 70 °F before the commencement of treatment. (This usually insures that the required minimum treatment temperature of 115 °F shall be achieved within the first 5 minutes of treatment.) The requirement of having fruit at or above 70 °F (in the case of mangoes) prior to hot water treatment may not be met (a) when the fruit have come directly from a refrigerated room, (b) when the weather is rainy or cloudy, or (c) in the early morning hours. These conditions may cause a treatment facility to close temporarily until the fruit pulp temperature has warmed sufficiently to allow treatment.

It is the usual practice at many facilities to use the hoist to hang a basket of fruit a few inches above the surface of the hot water tank prior to submerging it. However, except for the bottom layer of fruit in the basket, the fruit do not absorb a sufficient amount of heat to make this a practical means of pre-warming the entire basket load. To accelerate the pre-warming process, several viable options are available. APHIS suggests the following methods for pre-treatment warning:

Treatment Tank

In tanks that treat a single basket (cage) of fruit at a time, pre-heating may be accomplished within the tank itself, by use of a timer or delay switch. (The extra time in the water is not considered as part of the treatment, but is in addition to the treatment.) This approach, however, is not feasible to use in a multi-basket tank (in which the baskets enter the tank at different times), and is not an approved option in this instance.

Separate tank

A separate hot water tank may be used for pre-heating purposes.

Heated air

Hot air may be blown onto the fruit.

Heated room

The fruit may be placed in a heated room.

Direct sunlight

The fruit may be exposed to direct sunlight (which may be magnified through glass).

Post-treatment Cooling Options

Cooling the fruit after hot water treatment is not an APHIS requirement. However, from the standpoint of fruit quality, many facilities choose to install a system to cool the fruit after removal from the hot water.

Refrigerated room

Hot water-treated mangoes may not be moved directly to a refrigerated room until at least 30 minutes following treatment. Allowing the fruit to simply stand for at least 30 minutes after removed from the hot water tank is thought to be helpful in killing immature stages of fruit flies, because the mangoes complete their “cooking” process during that time. The recommended storage temperature for mangoes is 55 °F to 57 °F (12.8 °C) at 85 to 90% relative humidity. This delays softening and prolongs storage life to approximately 2 to 3 weeks.

Fans

APHIS allows the use of fans in the screen room to blow air over the fruit as soon as they are removed from the hot water tank (if desired). However, the ambient air must not be less than 70 °F.

Hydrocooling

APHIS allows the use of a cool water tank or shower system, but with the following provisions:

Hydrocooling (either by showering or water immersion) is optional. However, it *may not be done* until a waiting period of at least 30 minutes has elapsed, after the fruit have been removed from the hot water tanks. During the waiting period and hydrocooling period, the mangoes must be safeguarded in a room or tunnel, separate from the hot water tanks. Water temperature used during hydrocooling is not regulated. However, if it is too cool (below 65 0 F), it may cause some of the fruit to split their skins, making them unmarketable. Water

used for hydrocooling should be chlorinated (50 to 150 ppm). Any other chemicals, such as fungicides, are optional, but must be approved in advance by FDA.

Changes

Hot water immersion treatment facilities whose construction was approved under earlier guidelines may continue to operate with APHIS approval. Newer facilities, however, are required to meet the current requirements outlined in this Checklist, which in most cases are more strict.

Once Oxford Plant Protection Laboratory has formally approved the plans and drawings for a hot water immersion treatment facility, the facility may make no further changes in the equipment without APHIS approval. Any proposed changes or improvements must be described in writing (with accompanying drawings, if necessary), and must be approved by APHIS in writing. Examples of proposed changes include adding additional treatment tanks, adding a cold storage room, and changing the model of the temperature recorder.

Safety and Health Checklist

- An adequate lavatory.
- Fire extinguisher, located near the boiler.
- First-aid kit, located near moving machinery.
- Hard hats for use by workers and visitors in the treatment and loading areas. (This is optional if not required by local regulations.)
- Approved safety ladders or walkways (catwalks, etc.) for use in observing treatment tank operations.
- Electric power must meet safety code requirements. Electrical wiring, including switches and other connections, shall be contained in metal or PVC conduit, and grounded to prevent electrical shock.
- Steam and hot water pipes shall be insulated or otherwise protected.
- Sufficient lighting shall be provided in working areas.
- Engines, pulleys, drive belts, and other hazardous moving parts, if located within 6 feet of floor level, shall be guarded with a safety shield or barrier.

- The admission of children or unauthorized persons into the treatment and packing areas shall be prohibited, if not accompanied by a responsible employee.

Dirty water in the tanks is a health concern, as well as an embarrassment to the operator. The APHIS inspector can provide advice on how often the water should be changed. In addition, APHIS recommends that operators should install a light sensor in each tank, to monitor the turbidity of the water.

Work Plan

A Work Plan is a formal agreement, signed by a representative of each treatment facility in a particular country, the Agriculture Ministry of the host government, and by USDA-APHIS. Work Plans govern the day-to-day operations of each facility, and may be improved from one year to the next. Work Plans usually contain additional provisions not included in this Checklist.

Fruit exporters are required to operate under general APHIS monitoring, and to be in full compliance with all APHIS regulations, as outlined in detail in the current Work Plan. The operator of the facility, as well as the inspector assigned to the facility should each keep a copy available, to resolve any disputes.

Start-up Costs and Resources

Currently, a modern two-tank system typically costs from $100,000 to $200,000 to build. Additional funds, about $40,000 to $50,000, are needed for installation. These costs do not include the land, building, and the various infrastructure that may be needed, such as fruit sizing equipment, packing tables, and cooling rooms. APHIS requires the exporter to sign a cooperative service agreement and to make an advance cash deposit into a trust fund, which will be used to pay for transportation, lodging, meals, incidental expenses, and salaries of inspectors sent on temporary duty to the facility, to conduct the official performance tests, and to monitor treatments. If several treatment facilities are located near one another, they may sometimes be allowed to share the cost of services provided by one inspector. APHIS is a regulatory agency of the U.S. Department of Agriculture, and cannot become involved in financing commercial enterprises.

See **Appendix H** for manufacturers, suppliers, engineering firms, and consultants for hot water immersion treatment facilities. These resources are found under the following categories:

- Balances, Portable
- Batch Systems (Completes Installations)
- Temperature Recorders (Including Installation)
- Temperature Sensors (RTD, 100 ohm)
- Thermometers, Glass-Mercury, Certified Precision (used as a calibration standard)
- Digital Thermistor Instrument (hand-held) and Portable Sensors (used in Performance Test)
- Continuous Flow Systems (Complete instrumentations)
- Steam Boilers
- Chain Hoist (Electronic)
- Fruit Crates, (Plastic)
- Fruit Sizing Equipment (Automatic)
- Screening and Netting (Fly-Proof)
- Safety Equipment
- Consultants